

smoothly varying gain of the imager and probe with range; acoustic power performance; and imager parameters, like its preamplifier input impedance, noise level and temperature drift.

[0037] In accordance with the preferred embodiment, the resolution and sidelobe requirements are specified both for azimuth (conventionally, the imaging dimension) and elevation (the slice thickness direction). The systems engineer quantifies the importance of these (or other) image quality metrics with numeric values that usually vary with range. These will be referred to in this disclosure as "Y's". As previously discussed, the Transducer Design Advisor 10 is used to specify some of the characteristics of a probe to meet the requirements.

[0038] In accordance with the preferred embodiment of the invention, a controller 26 is provided for performing a statistically designed simulation. The DOE controller 26 varies the x's in a designed experiment whose character and resolution are chosen by a DOE advisor (a user interface "wizard" similar in functionality to the Transducer Design Advisor and forming part of the DOE controller 26). The DOE advisor is a small expert system that chooses the type of designed experiment appropriate for the case under study. Designed experiments allow all of the x's to vary simultaneously to capture their effects on the image quality Y's, with an optimally small number of simulation runs.

[0039] The beam simulator generates an image; it computes the diffraction of the sound from the aperture to the scatterer locations, the scattering itself, and the diffraction back to the aperture. This image 20 can be reviewed visually (for example, on the display monitor of the user's PC) for artifacts. For the purpose of making transfer functions, the customer value of the image is scored, based on the image quality specification:

$$Y = \sum_{i=1}^M \sum_{j=1}^N c_i(r_j) y_i(r_j)$$

where y_i is the i -th of M image quality parameters, r_j is the j -th of N ranges in the image, and c_i is a range-dependent value coefficient for the i -th image quality parameter. The $c_i(r_j)$ form the image quality specification 6 mentioned earlier. The Y 's are indicated by block 24 in FIG. 1.

[0040] The y_i are normalized with respect to a "nominal" design. They therefore represent the percentage improvement or degradation of a certain DOE parameter set. The coefficients in the image quality specification can therefore be viewed as answering the question: "How much does the user care about a 1 percentage point improvement in this CTQ, compared to a similar improvement in other CTQs?"

[0041] The DOE controller 26 comprises a regression tool which generates transfer functions (step 28 in FIG. 1) from the simulation-based data. The DOE controller can automatically import the DOE data and produce $Y = f(x)$. The DOE controller further comprises a transfer function tool which imports the generated transfer functions and represents them numerically in a spreadsheet. The transfer function tool will also generate diagnostic data (such as correlations and sensitivities) and three-dimensional visualization.

[0042] The transfer functions relate each x to each y , and the x 's to the overall image quality, denoted by Y :

$$y_i = f_i(x_1, x_2, x_3, \dots, x_L)$$

$$Y = F(x_1, x_2, x_3, \dots, x_L)$$

The business value of these transfer functions is threefold:

[0043] First, plots of the transfer functions will aid a skilled probe designer. The effect of each of the x_k on the parameters of the image CTQs y_i and the overall performance Y can be quickly visualized through main effects plots. This builds intuition in an uncertain environment. The quantitative effect of each tradeoff is made plain.

Second, the partial derivatives

$$\frac{\partial y_i}{\partial k_k} \text{ and } \frac{\partial Y}{\partial k_k}$$

show the sensitivity of the design to manufacturing variability. The computation of transfer functions provides a far more complete picture than was previously available using the standard design practice of "point" performance evaluations.

[0044] Third, the transfer functions can be used to optimize the performance and robustness of the design. Details of this are shown in FIG. 2.

[0045] Since transfer functions can be evaluated with many orders of magnitude less resources than the imager simulation, the optimization of the imager parameters can proceed with large numbers of x 's and Y 's, at modest computational cost. FIG. 2 shows how to optimize both the image quality (y_i and Y) and the variance of these parameters. The variances of the x 's are specified by the manufacturing database for each x , together with the cost associated with each tolerance level. The output of this process will look as is shown in FIG. 3. This final output of the statistical design method enables a data-driven decision on product positioning in the marketplace. This graph is the precise distillation of information needed to optimally target the product. For each cost, an image quality measure has been computed, which is the best available under the cost constraints. The image quality measure directly was determined from Systems Engineering's specification of the probe. The error bars show the variation in image quality given the tolerances available at that cost.

[0046] In accordance with the preferred embodiment, the software components are distributed between a user's PC 80 and a remote server 82, as shown in FIG. 4, PC 80 and server 82 being connected via a network 84, e.g., a local area network or wide area network. The remote